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CHINA REPORT
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APPLIED SCIENCES

CDMA SATELLITE COMMUNICATIONS SYSTEM ADVANTAGES LISTED

Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese No 1, 1982 pp 19-26

[Article by Mao Yuhai [5403 0060 3189] of Qinghua University: "Some Considerations of the CDMA Satellite Communications System"; this article received by this journal on 29 August 1981, was written in 1980 when the author was working at the RCA Company in the United States]

[Text] This article discusses the possibility of placing a new CDMA communications satellite between two SCPC communications satellites on two orbits 4° apart in space. The article gives the relationship between the power density per bit/noise and the number of users of the CDMA system. It discusses the method of increasing the number of users, calculates the mutual interference of the CDMA system and the SCPC system, and derives the ratio between the power density of maximum interference and the power density of receiver noise for the maximum number of users.

I. Introduction

As satellite communications develop, the number of synchronous communications satellites on the same orbital arc will increase. The smallest distance between two neighboring satellites was originally limited to 4 degrees. If the distance between neighboring satellites is further shortened, intolerable mutual interference will result. Because the frequencies assigned to neighboring satellites are the same, interfering signals will easily enter the side lobes of the ground station antennas.

There are two types of interference: upward interference and downward interference. Upward interference is caused by the transmitter of the ground station. The signals transmitted reach the neighboring satellite through the side lobes of the transmitting antenna of the ground station. Downward interference is caused by the neighboring satellite. The interfering signal enters the receiver of the ground station via the side lobes of the receiving antenna of the ground station. Because the upward and downward frequencies are different, the transmitting wave lobe diagram and the receiving wave lobe diagram of the same antenna are slightly different.

There are many ways to solve the problem of mutual interference. For example:

1. The electrical level of the side lobe of the antenna can be lessened. The electrical level of the side lobe of a carefully designed parabolic antenna can be as low as -25 to -30 dB; i.e., about 5 to 10 dB lower than that of presently available ground station antennas.
2. A multiple wave beam satellite can be used. It operates under the satellite switched time division multiple access (TDMA) system, thus reducing the interfering signals from the ground stations located outside the pin beam.
3. The problem of mutual interference can be solved using code division multiple access (CDMA) of the expanded frequency spectroscopic technique. This is the purpose of this article.

This article will emphasize the discussion of a satellite communications system with directly sequenced PN code division multiple access.

II. The Number of Users of a Code Division Multiple Access System

We very naturally think of the following problem: on the same marked carrier frequency, can a system of expanded frequency spectra transmitting and occupying the same radiofrequency bandwidth accommodate the same total number of users as an ordinary frequency division multiple access system? In an ordinary frequency division multiple access system, the number of users can be determined by the ratio between the system's bandwidth and the bandwidth of the communications channel. For example, the radiofrequency bandwidth in the SPADE system is 36 MHz. The bandwidth of each channel is 38 KHz. The interval of each carrier wave is 45 KHz, and so the total number of communications channels is equal to $36 \text{ MHz} / 45 \text{ KHz} = 800$.

To determine how many simultaneous users of expanded frequency spectra there can be within a given frequency band, we must mainly rely on calculating the signal-to-noise ratio at the output end of related equipment. But it is very difficult to derive a meaningful and generalized result. Therefore, the following discussion will be limited to the ideal hypothesis of complete statement synchronism and bit synchronism. In addition, the following hypotheses are also made:

1. We assume that the long code is used, or when there are many users, many short codes are used. It is possible in this way to suppose that the effects of other users can be replaced by the Gaussian random process.
2. We assume that the processing gain is very large. This means we assume that the ratio between the expanded bandwidth B_r and the information bandwidth B_m is very large. A large processing gain can make the above hypothesis more reliable--i.e., the effects of other users can be regarded as blank noise processes in the data bandwidth.

These hypotheses are relatively conservative.

Let the receiving signal power be P_r and the bandwidth of the receiver be B_r ; the receiving signal power density then is equal to P_r / B_r , and the mutual interference noise of the other $n - 1$ users N_m is equal to

$$N_m = \frac{n-1}{n} \cdot \frac{P_r}{B_r} \approx \frac{P_r}{B_r} \quad (1)$$

where n is the number of simultaneous users. If the receiver noise power density is represented by N_r , then the total noise power density N_o equals

$$N_o = N_r + N_m = N_r + \frac{P_r}{B_r} \quad (2)$$

If the signal power received by a single user equals P_r/n , then the signal energy E_b per bit equals

$$E_b = \frac{P_r}{n} \cdot \frac{1}{R_b} \quad (3)$$

where R_b is the bit code rate of the information code. Now we can write the ratio of the power density of each bit of energy and noise as follows:

$$\frac{E_b}{N_o} = \frac{\frac{P_r}{n} \cdot \frac{1}{R_b}}{(N_r + N_m)} = \frac{\frac{N_r B_r}{n R_b (N_r + N_m)}}{\frac{N_m B_r}{n R_b (N_r + N_m)}} \quad (4)$$

The information bandwidth B_m equals $2R_b$. The processing gain G of the direct PN code system equals the ratio between the system's bandwidth and the information bandwidth. Although there are many other formulas which can more accurately compute the processing gain (for example, refer to reference 1), this is sufficient for engineering estimates. Therefore, equation (4) can be rewritten as

$$\frac{E_b}{N_o} = \frac{2G \alpha}{n(1+\alpha)} \quad (5)$$

where $\alpha = N_m / N_r$. It is the multiple of the power density of mutual interference over the receiver noise density.

E_b / N_o takes the processing gain G and the power density ratio α as parametric variables. The curve of the relationship between it and n is shown in Diagrams 1 through 3. They correspond respectively to $G = 500, 1000, \text{ and } 2000$.

If we assume that the added noise in the communications channel is blank Gaussian noise, then the bit error probability is

$$P_E = \left(\frac{1}{2} \operatorname{erfc} \left[\left(\frac{E_b}{N_0} \right)^{1/2} \right] \right) \quad (6)$$

where erfc is the error function, defined as

$$\operatorname{erf}(x) = \frac{2}{\pi} \int_x^{\infty} e^{-u^2} du \quad (7)$$

From equations (6) and (5) we can obtain the relationship between P_E and n , as shown in Diagrams 4 to 6, which correspond respectively to $G + 500$, 1000 , and 2000 .

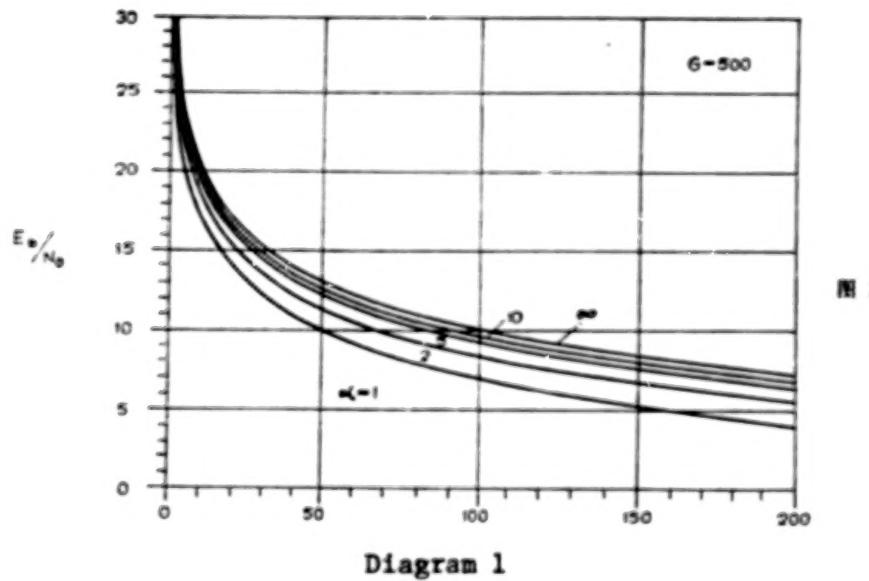


图 1

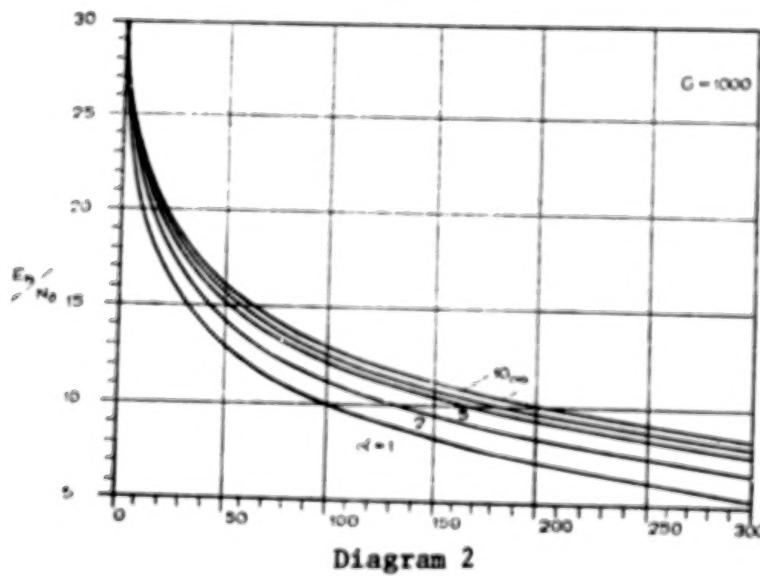


图 2

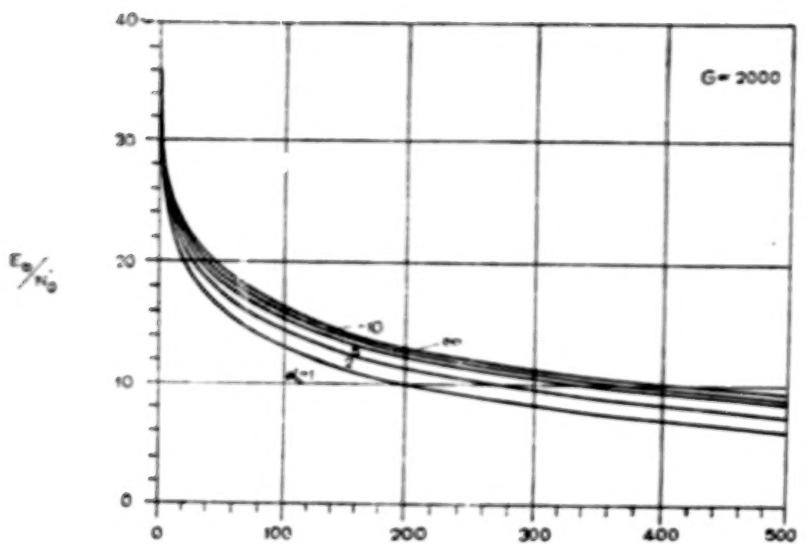


Diagram 3

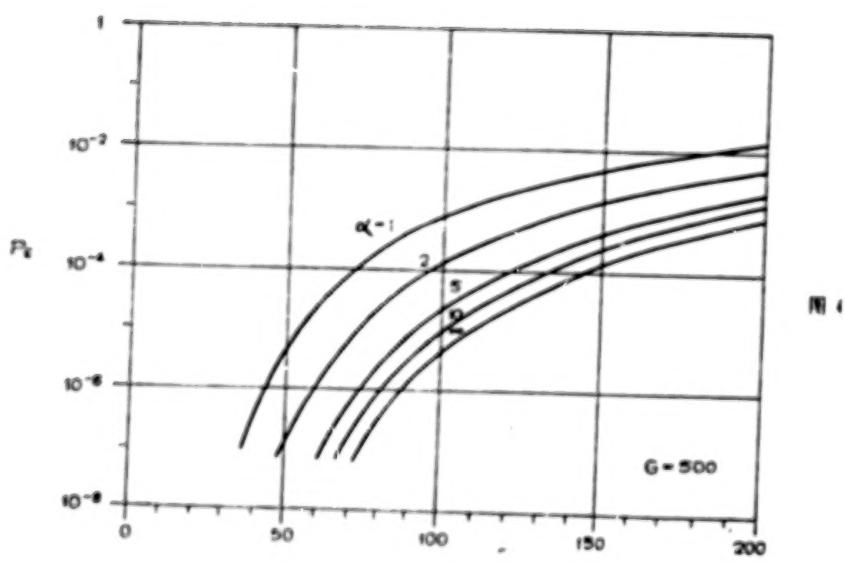


Diagram 4

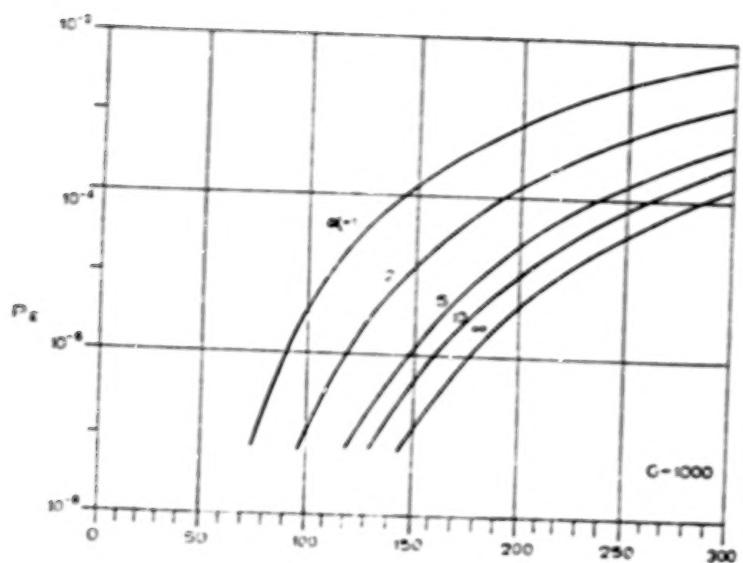


图 5

Diagram 5

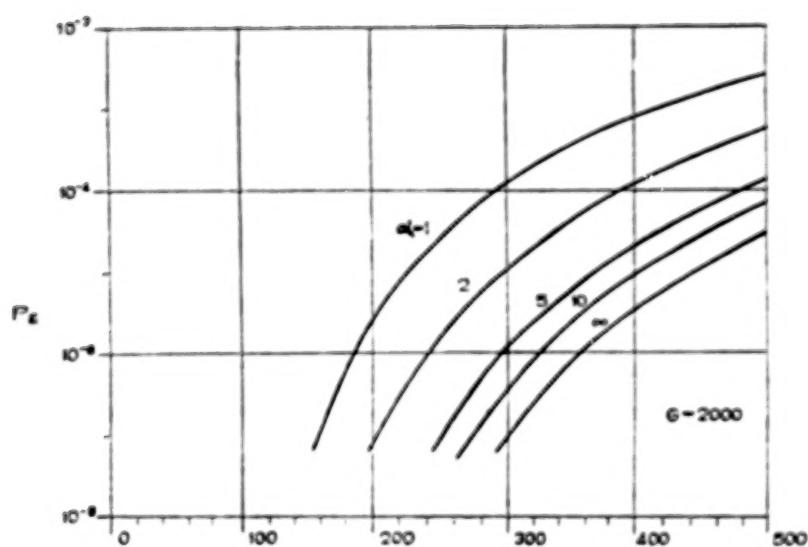


图 6

Diagram 6

III. The Method of Increasing the Number of Users

First, let us decide on the processing gain of an actual code division multiple access (CDMA) system.

The bandwidth of the receiver equals 36 MHz. This is determined by the actual satellite retransmitter. The bandwidth of information is determined by the method of modulation. The PCM code rate is the highest. If the sampling rate of the voice channel is 8,000 samples/second, and each sample is quantified as 7 bits plus 1 bit as the added signal, then the digital code rate is 64 kilobits/second. The code rate of Δ modulation is far smaller than ordinary PCM. The digital code rate of the DET-56 digital ground station is 32 kilobits/second. When the digital code rate is reduced to 16 kilobits/second, acceptable voice quality can still be maintained. Therefore, we first consider Δ modulation here.

Although the bandwidth of QPSK is only one-half of the BPSK when the data rate is the same, the processing gain of direct PN code division multiple access is the same, regardless of whether it is in QPSK or BPSK. The reason is that the processing gain is determined by the span-versus-width ratio of the frequency band, and so therefore conservation of the bandwidth will not benefit the expansion of the frequency band. Concretely, in the situation we are discussing, the limit of the radiofrequency bandwidth is 36 MHz. After using QPSK, the rate of the PN code can be allowed to increase onefold. This means that for QPSK, $R_c = 36$ MHz, but for BPSK, $R_c = 18$ MHz. But the bandwidth of the two systems is the same, and so the processing gain is the same for both systems. If we use Δ modulation, the information code rate is 32 kilobits/second, then the processing gain is generally equal to 500. If the information rate is reduced to 16 kilobits/second, then its processing gain will approach 1000. It can clearly be seen in Diagrams 1 through 3 that when the ratio of the power of each bit versus noise E_b / N_0 is given, the number of simultaneous users is determined by the processing gain G and the ratio α between the mutually interfering noise and the receiver noise. If $E_b / N_0 = 10$ dB, $G = 500$, $\alpha = 1$ are given, then the number of simultaneous users is only 50. If α increases from 1 to ∞ , then the number of users can increase from 50 to 100. If G increases from 500 to 1000, then at $\alpha = \infty$ the number of users can increase from 100 to 200.

The required E_b / N_0 is determined by the allowable bit error probability. Therefore, using the error-correcting code can also increase the number of users. The most effective error-correcting code is the convolutional code with software decided Viterbi decoding. Concretely speaking, we have considered the convolutional code with 8-level software decided Viterbi decoding. Its limiting length is $K = 7$, and its rate is $R = 1/2$. The accompanying table 2 lists the performance of this type of code in the added blank Gaussian noise when the error code rate is from 10^{-6} to 10^{-3} . Yet, using error correcting codes will cause the frequency band to expand, and the processing gain will be lowered. For example, the convolutional code of $K = 7$ and $R = 1/2$ will expand the information bandwidth to onefold the original bandwidth. This means the processing gain will be reduced by onefold. Yet, even when the processing gain is reduced, the number of users will still increase. For

example, if $G = 1000$, $i = 1$, the required error code rate would be 10^{-6} , and this corresponds to the required $E_b/N_0 = 10.5$ dB before coding. We can obtain the number of users from Diagram 2 to be about 85. Yet, if error-correcting codes are used, the required E_b/N_0 will be reduced to 5.0 dB. Even though at this time the processing gain has dropped to 500, the final number of users can still be increased to 160 (see Diagram 1). But this number is still far lower than that of the frequency division multiple access (FDMA) system. In this example, the frequency spectrum utilization rate is low because it contains the hidden hypothesis that all users are continuously operating, or at least are operating at a very high work ratio. In this situation, the system of expanded frequency spectra usually cannot utilize the frequency spectra very effectively. Yet almost as early as 20 years ago, Costas [3] had already proven the following conclusion: If we want a group of stations to be able to work anytime, but each station works only a short period, the broadband system must provide a greater communications capacity and a greater frequency spectra utilization rate with a narrowband system.

具有 Viterbi 解码和软判决的卷积码 ($K=7$, $R=1/2$) 的性能

1 级 别 *	2 级 别 *	3 级 别 *
P_e	E_b/N_0	E_b/N_0
10^{-2}	10.5 dB	2.0 dB
10^{-4}	9.6 dB	4.5 dB
10^{-6}	8.4 dB	3.8 dB
10^{-8}	6.6 dB	3.0 dB

Performance of a Viterbi decoding and soft-decision convolutional code ($K = 7$, $R = 1/2$)

Key:

1. Error-code rate
2. Uncoded
3. Coded

When operating in a crowded frequency band, different tasks are often assigned to different frequency bands while the user is allowed to operate on any frequency in the frequency band. Costa proved that when the communications capacity of the broadband system surpasses that of the narrowband system. The capacity can be represented by the following formula

$$C_B = C_N [1/d(S/N)_{\min}] \quad (8)$$

Where C_B , C_N = the communications channel capacities of the broadband and the narrowband in operation, d = the average work ratio of each station, and

$(S/N)_{\min}$ = the estimated most unfavorable signal-to-noise ratio in the narrowband system.

It can be seen from equation (8) that as the work ratio drops, the superiority of performance of the broadband system over that of the narrowband system increases.

When all the users are able to operate at their assigned frequencies, Costas also proved that a similar relationship exists—i.e., when the different assigned tasks are given a bandwidth, the broadband system that operates at a low work ratio can provide a larger communications capacity. The reason is that when the work ratio is low, at any given instant most of the assigned communications channels are free, and so therefore the narrowband system creates a waste of the frequency spectra. This is unavoidable, however, because each station is prepared to use the channels at any time. This type of narrowband distribution eliminates interference between users. In the broadband, the influence of each station on the other station is like "noise"; therefore, it can benefit from a low work ratio. So long as the average electrical level of the "noise" does not surpass the allowable capacity limits, the number of users of the system can be increased.

Ordinarily, it is very difficult to calculate accurately the number of users at a low work ratio. This is because it is determined by the distribution of the operating time of the users. This kind of distribution can be measured in an actual satellite communications system. A mathematical model can be obtained from the measured data. But we can obtain a rough estimate from equation (8). The number of users of a communications system of expanded frequency spectra is inversely proportional to the work ratio. The average work ratio of an actual satellite communications system during the daytime is about 0.25. Therefore, the potential number of users is about 4 times the number of simultaneous users. Concretely speaking, in the examples we have cited it is possible to have 600 potential users.

IV. Interference of the Current SCPC System by the CDMA Satellite Communications System

The signals of the expanded frequency spectra enter the current SCPC system via the side lobes of the ground station antennas. The gain of the side lobe of the ground station antenna is given by the following formula:

$$G(\theta) = 32-25 \log \theta^0 \text{ (dB)} \quad (9)$$

The newly added satellite is 2 degrees away from the present satellite. Substituting into equation (9), we obtain $G(2^0) = 32-25 \log 2 = 24.5$ dB. The gain of the main lobe of a standard ground station antenna is 43 dB at 4 GHz, and 46 dB at 6 GHz. Therefore, the difference between the electrical levels of the upward and downward side lobes is 3 dB. In the worst case, the electrical level of the side lobe is lower than the electrical level of the main lobe by $g(2^0) = -18.5$ dB (i.e., 0.014).

According to the hypothesis in Section 2, the signal of the expanded frequency spectrum can be simulated by Gaussian blank noise with a power density of N_m . Therefore, the interference power density received by the present SCPC ground station is $g(\theta)$, $N_m = 0.014N_m$. This is equivalent to increasing the power density of noise of the ground station by one factor, equal to $[1 + g(\theta)] = (1 + 0.014\alpha)$. This will reduce the number of effective users of the SCPC system by the same factor, because an increase in the noise power means an increase in the carrier wave power. But the total power is limited by the specified power of the carrier wave tube, and so its number of carrier waves must be reduced.

Therefore, if we increase the power density ratio α , then although the number of users of the CDMA system can be increased (See Diagrams 1 through 3), the interference of the present SCPC system will also increase. Therefore, the total number of users will increase at a smaller α . When α increases further, the number will reduce. When we insert a new CDMA communications satellite, two of the existing neighboring satellites (carrying the SCPC communications system) will both receive interference. Therefore, the total number of users n_o can be determined by the following formula:

$$n_o = \frac{2G\alpha}{E_b/N_o(1+\alpha)} + \frac{2N_s}{1+g(\theta)\alpha} \quad (10)$$

where n_s is the number of communications channels of the SCPC system. If the number of communications channels of the SPADE system $n_s = 800$, $g(\theta) = 0.014$, then substituting into equation (10) we can draw the relationship between n_o and α when (E_b/N_o) and G are used as parametric variables. The results are shown in Diagrams 7, 8, and 9.

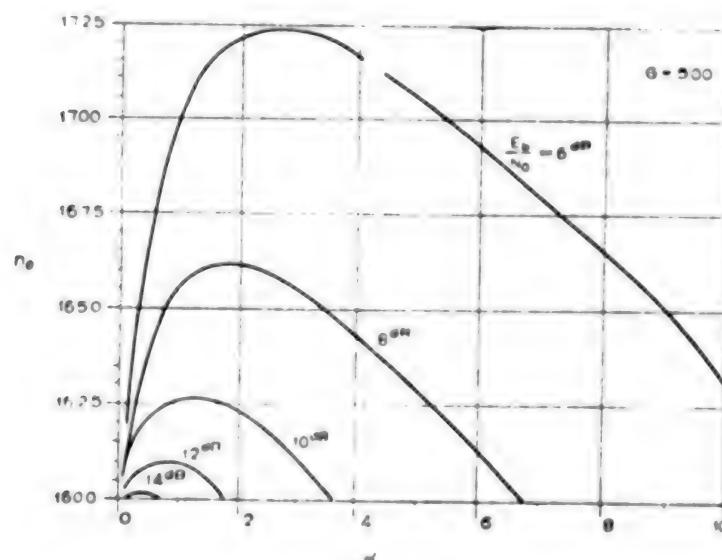


Diagram 7

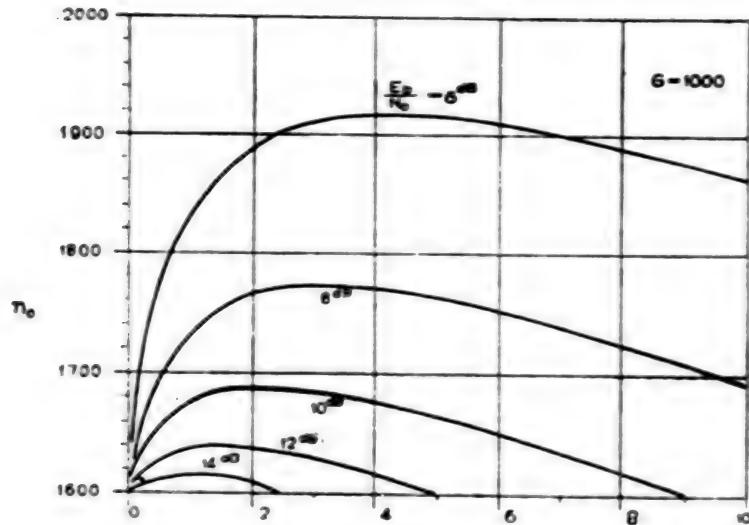


Diagram 8

We can draw the following conclusions from these curves:

- (1) There is a maximum value on each curve.
- (2) When the processing gain is relatively low, the maximum value is more sensitive to α .
- (3) When the required E_b / N_o is reduced, the maximum value of α will increase.
- (4) When $G = 500$, within the range of the values of E_b / N_o that we are actually interested in, the value of α is between 1 and 3.

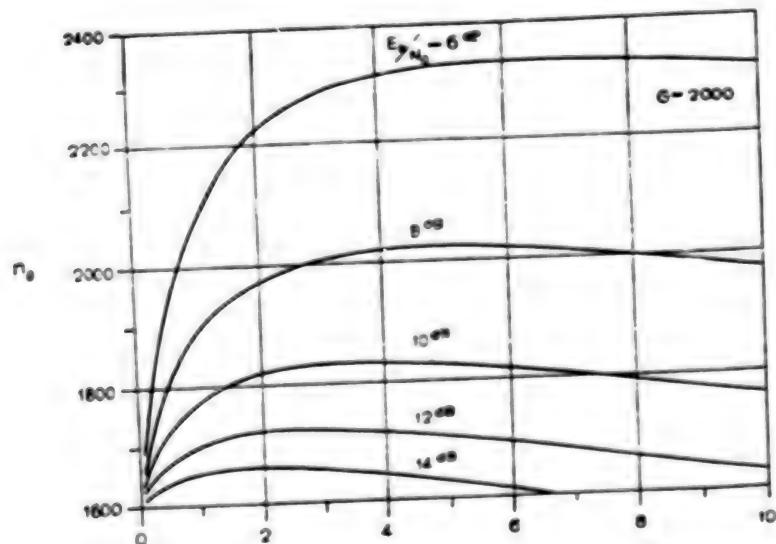


Diagram 9

V. Interference of the CDMA System by the SCPC System

There are many carrier waves within the radiofrequency bandwidth of the SCPC System. If the radiofrequency band of the SCPC system completely overlaps the CDMA system, this type of evenly distributed small carrier waves can be approximately regarded as being Gaussian blank noise. With this assumption, the calculation of the interference of the CDMA system by the SCPC system becomes very simple.

The interference signals of the SCPC system also enter the CDMA system via the side lobes of the ground station antennas of the CDMA system. They will also cause the power density of equivalent noise at the receiver to increase by a multiple of $[1 + g(\theta)P_c / N_r B_c]$, where P_c / B_c is the carrier wave power density of each communications channel of the SCPC system. This will cause the parameter α to drop by the same multiple. For example, if $P_c / B_c N_r = C/N_0 = 12$ dB and $g(\theta) = 0.014$, this factor will equal 1.151. It can be seen from Diagrams 1 through 3 that α is reduced by 1.15 times, and this will not visibly worsen the CDMA system. If we hope to obtain a more accurate computation, we can substitute the new value of α into the previous formula, and the result obtained will correspondingly change.

VI. Conclusion

It is possible to add a CDMA communications satellite between two SCPC communications satellites without worsening the performance of the former. The number of users of the CDMA communications system must be fewer than the number of users of the SCPC system. Yet the number of users of the CDMA system can be increased by using error-correcting codes. The potential number of users is comparable to that of the SCPC system. Many other advantages (such as ability to resist interference, ability to resist attenuation, etc.) make the CDMA system especially suitable for use as a special-purpose communications system.

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APPLIED SCIENCES

POWER SEMICONDUCTOR DEVICE APPLICATIONS REVIEWED

Xian DIANLI DIANZI JISHU [POWER ELECTRONICS] in Chinese No 1, 1982, p 35-41

[Article by Zhang Weizuo [1728 3634 0146] of the Xian Rectifier Research Institute: "The Development of Electrical Semiconductor Devices as Seen in Electrical Appliances for Everyday Use"]

[Text] During the past 2 years, our nation's ordinary, everyday electrical appliances have developed rapidly. They had made corresponding demands for various types of low-power thyratron transistors. On this basis, many manufacturers are competing to produce these types of devices. This article will introduce in general those devices which are related to everyday electrical appliances; emphasis will be placed on a further description of the bidirectional thyratron transistor and related triggering devices. Some immature views on the varieties and direction of development and the key points of related technologies will be presented.

I. The Demand Made by the Development of Daily Electrical Appliances Upon Electrical Semiconductor Devices

There are many kinds of electrical appliances for everyday use, but in general, such electrical appliances that utilize electrical semiconductor devices can be divided into three major categories for controlling electrical motors, for temperature control, and for brightness control. There are other people who have classified them further into seven categories, as Table 1 shows.

Obviously, Table 1 shows many applications, but it still does not include all electrical devices for daily use that are being developed domestically and abroad. Some devices are comprehensive controlling devices belonging to several categories, and to list them in a certain controller category would not be precise enough. But Table 1 also shows a general view and the important function of electrical semiconductor devices in electrical appliances for daily use. The electrical semiconductor devices discussed here refer mainly to the various thryatron transistors. If we included the transistor, the diode, the voltage stabilizer, the range would be even broader. But according to reports, household appliances tend to use the thyratron transistor. This is the result of the rapid development of household electrical appliances toward sophistication. Some simply electrical devices use the diode to chop off the half-wave, and its control fuction obviously is not as continuous as that of the thyratron transistor. In phase control, the number of components used

by the thyratron transistor or the bidirectional thyratron transistor is less than those of the transistor, and the power is low. These are all reasons for the rapid development of the various types of thyratron transistors used in household appliances.

Table 1 Range of Application in Everyday Electrical Devices, Function of the Electrical Circuits and Suitable Devices

表1 日用电器的应用领域、电路机能及适用器件

(1) 应用领域	(9) 具体应用	(17) 电路机能	(25) 适用器件
(2) 电动机控制	(10) 电扇、洗衣机、吸尘器、电动缝纫机、电动工具、空调风机、排风机、电动玩具、搅拌器	(18) 相位控制	(26) 双向晶闸管、普通晶闸管
(3) 温度控制	(11) 电熨斗、吹风机、保温器、电气毛毯、电褥、电热杯、电热梳、电烙铁、各种电炉烤炉电子灶	(19) 相控及通断控制	(27) 双向晶闸管
(4) 光控制	(12) 白炽灯萤光灯调光、广告照明、交通信号、显示装置、黑相用闪光器、音乐闪光装置	(20) 相控及通断控制、斩波器	(28) 双向晶闸管、普通晶闸管
(5) 脉冲控制	(13) 煤气炉、煤气灯点火、萤光灯、钠灯启动、汽车点火	(21) 直流开关	可关断晶闸管、普通晶闸管、双向晶闸管、硅对称开关 (29)
(6) 电源开关及控制	(14) 电视电源调节器、汽车电源调节器、充电器、冰箱、定时器、固态继电器、门自动开关、抚摸式开关、微波炉	(22) 相位控制、斩波器、通断控制、开关	普通晶闸管 程控单结晶体管 双向晶闸管 (30)
(7) 防灾机器	(15) 火警器、煤气警报器、漏电断路器	(23) 直流开关	普通晶闸管 可关断晶闸管 (31)
(8) 频率变换	(16) 电视水平偏转、电磁灶、超声洗涤器、电子乐器	(24) 逆变器	可关断晶闸管 不对称可控硅 逆导晶闸管 (32)

Key:

1. Range of Application
2. Controlling electrical motors
3. Temperature control
4. Light control
5. Pulse control
6. Power source switch and control
7. Disaster prevention devices
8. Frequency changes
9. Actual applications

Key continued:

10. Electric fans, clothes washers, vacuum cleaners, electrical sewing machines, electrical tools, air conditioning ventilators, air ventilators, electrical toys, mixers
11. Electric irons, blowers, thermostats, electric blankets, electric mattresses, thermoelectric cups, thermoelectric combs, electric irons, various electric stoves, electric ovens, electronic stoves.
12. Ordinary light bulb and fluorescent lamp dimmers, lighting for billboards and neon lights, traffic signals, display devices, photographic flashes, visual color synthesizers for stereo music.
13. Coal gas burners, igniting devices for coal gas lamps, turning on fluorescent lamps and sodium lamps, automobile ignitions
14. Television power source regulators, automobile power source regulators, chargers, refrigerators, timers, solid state relays, automatic door-opener switches, touch-operated switches, microwave ovens
15. Fire alarms, coal gas alarms, leakage circuit breakers
16. Television horizontal dials, electromagnetic stoves, supersonic washers, electronic musical instruments
17. Functions of circuits
18. Phase control
19. Phase control and on-off control
20. Phase control and on-off control, wave chopper
21. Direct current switching
22. Phase control, wave chopper, on-off control, switching
23. Direct current switching
24. Inverse transformer
25. Suitable devices
26. Bidirectional thyratron transistor, ordinary thyratron transistor
27. Bidirectional thyratron transistor
28. Bidirectional thyratron transistor, ordinary thyratron transistor
29. Thyratron transistor that can be switched off, ordinary thyratron transistor, bidirectional thyratron transistor, silicon symmetric switches
30. Ordinary thyratron transistor, process control unijunction transistor, bidirectional thyratron transistor
31. Ordinary thyratron transistor, thyratron transistor that can be switched off
32. Thyratron transistor that can be switched off, asymmetric silicon controller, reverse thyratron transistor

1. Control of Electric Motors

In controlling electric motors, the most familiar are the electric fan and the clothes washer. The variation in the speed of ordinary electric fans is generally between 60 percent and 80 percent. Using semiconductor devices to regulate speed can reduce the maximum speed of revolution to below 30 percent. Also, a starting compensator circuit can be used to increase the conducting angle of the bidirectional thyratron transistor at low speed when starting to overcome frictional torque. Besides using the bidirectional thyratron transistor for phasing and for speed regulation, ordinary thyratron transistor

can also be used as a switch to switch the excited magnetic head of the electric motor to realize speed regulation, and the thyratron transistor can be controlled by a small electric current from the human body touching a face-board, thus grounding the current for switching.

Speed regulation in a clothes washer makes it easy for the machine to wash different types of materials (foreign nations believe there are 10 different types of materials, and the speed of revolution required is from 170 rpm to 500 rpm). Because the types of materials are different, the amount of clothing is different, and the amount of water is different, thus under a fixed operating voltage the torque of the load frequently changes, and therefore it is important to use speed feedback for automatic control. In the fully automatic clothes washer which uses a microcomputer, the valves and the clockwise and counterclockwise rotation of the electric motor can be realized by a five ampere bidirectional thyratron transistor, as shown in Diagram 1. As everyone knows, five bidirectional thyratron transistors can completely control the clockwise and counterclockwise rotation of the electric motor.

Another example of the popular use of the bidirectional thyratron transistor in electrical devices in daily use is the copier. Besides the electric motor that feeds the paper, the bidirectional thyratron transistor can control the high voltage for static electricity, the light source for image fixing, etc. as shown in Diagram 2. Of course, the power part still requires the use of rectifiers and voltage stabilizers.

Diagram 1 Block diagram of a fully automatic clothes washer

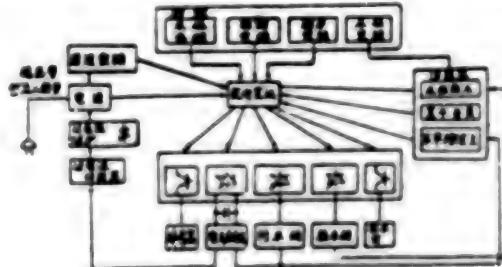


图 1. 全自动洗衣机方框图

Diagram 2 Block diagram of a copier

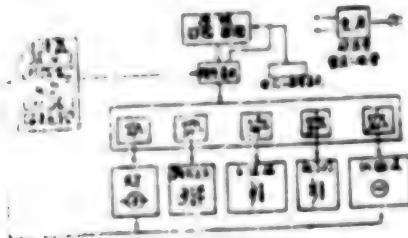


图 2. 复印机方框图

A bidirectional thyratron transistor for phasing and speed regulation in vacuum cleaners can regulate the input power at will between 100 watts and 500 watts. This enables the vacuum cleaner to suck in larger dust particles and can also conserve electricity.

Electric sewing machines generally use ordinary thyratron transistors for control. They also have a speed feedback circuit. The advantages are as follows: When the power is turned on and the speed of revolution of the motor is slow, the torque is high at low revolution speeds and the variation in speed caused by the load is small. Of course, the speed can be adjusted at will.

The classical example of an electric tool is the adjustable speed, handheld electric drill which uses a bidirectional thyratron transistor or ordinary thyratron transistor to realize phasing and speed regulation. But if ordinary thyratron transistors are used for half-wave control, the maximum output voltage is only half the voltage of the power source; therefore the coil of the electric motor must be redesigned. The speed-regulation circuit of the bidirectional thyratron transistor can be installed inside the handle of a handheld electric drill.

Air-conditioning equipment and kitchen ventilation shafts can all be fitted with an air ventilator with variable speed control.

2. Temperature control

There are many varieties of everyday electrical appliances that use temperature controllers. The methods of control are mostly the same. Generally speaking, there are two types; the phasing control, and the on-off control. The latter uses an over-zero trigger and is not affected by radiofrequency interference. It is also called a power adjuster. Because it is controlled by alternating current, the bidirectional thyratron transistor is especially suitable for use in temperature control.

At present, the more common device is the temperature-controlled iron. Electric mattresses have recently been introduced on the market. The temperature of the blowers of course can be adjusted. Except in industrial applications, there is still difficulty in popularizing those blowers, as they consume a lot of electricity in households.

3. Light control

Generally speaking, light adjustment is only phase control. It is estimated that light adjustment would be the most popular application, because the price of the controller is cheap, every family must use light bulbs, and all lamps, table lamps and wall lamps can be regulated. Our nation uses a lot of fluorescent lamps, and the bidirectional thyratron transistor can similarly be used to adjust the light of fluorescent lamps, as shown in Diagram 3. According to reports, Japan started out using regulators for fluorescent lamps in large buildings, conference rooms, and theaters, but now these regulators have become popular in ordinary households, teahouses, and restaurants. The silicon symmetric switch (SSS) can also be used for turning on fluorescent

lamps, as shown in Diagram 4. The bidirectional thyratron transistor is also used for turning on lights. It is characterized by a short starting time (reducing the time from the ordinary 3 to 5 seconds to 0.5 seconds). It has a long and useful life, and its price in Japan is about one and a half times the price of a starter.

Diagram 3 Example of adjusting the brightness of a fluorescent lamp

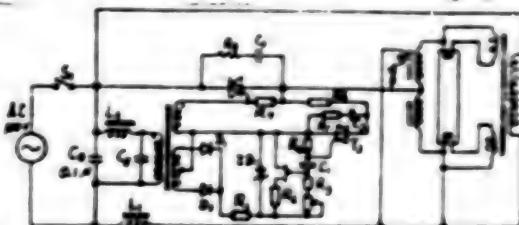


图3. 荧光灯调光例

Diagram 4 Example of starting a fluorescent lamp

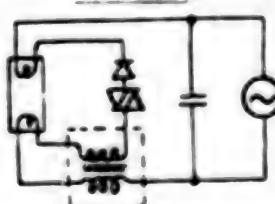


图4. 荧光灯启动例

4. Other types of control

The thyratron transistor is also used in television sets, tape recorders, and video recorders. The power source circuit of a television set can use a phase control of a wave chopper. The horizontal adjuster circuit can suitably utilize a thyratron transistor that can be switched off and a reverse thyratron transistor. The cassette tape recorder can utilize the thyratron transistor for automatic shutoff, automatic reverse, and automatic ejection control.

Refrigerators can use the bidirectional thyratron transistor for startup to reduce noise, and they can also use it as a switch for the defroster.

Induction heating can be used in the electromagnetic stove. In such stoves, only the cooking pot is the heat-emitting body. According to reports, heating is rapid and such stoves are most suitable for stir-frying food. The emergence of the asymmetric thyratron transistor (ASCR) has provided a type of device with a relatively high frequency and is suitable for induction heating.

Electronic games and toys frequently use a combination of various types of controls, such as electric motor controls, switch controls, light controls, etc.

Table 1 lists the functions of the circuits and the suitable devices of the various types of controls. It can be seen from the table that the most common are phase controls and on-off controls. Therefore, the bidirectional thyratron transistor occupies a very important position in electrical devices for daily use. The following section will center on an introduction to the bidirectional thyratron transistor.

The small power thyratron transistor is also a device that is broadly used. But in many situations it can be replaced by the process-control unijunction transistor (PUT), because PUT has a very small triggering current. But the transverse PUT voltage is relatively low.

The ideal device for a direct current switch is the thyratron transistor that can be switched off. Foreign nations are developing high-voltage and large-current thyratron transistors that can be switched off, and they are also developing low-power thyratron transistors that can be turned on and switched off with similar ease. The thyratron transistor that can be switched off is also suitable for use in inverters and wave-chopping circuits.

The use of reverse thyratron transistors for wave chopping is rational, but there seems to be less development of low-power reversing devices. The asymmetric thyratron transistor is a five-layer device specifically developed to regulate frequencies.

As new devices develop and as their cost drops, applications in these aspects will undergo more development. Triggering devices must be given more emphasis because they will more effectively develop the advantages of the main circuit elements. For example, better phasing can be obtained when a bidirectional thyratron transistor is controlled by a unijunction transistor, but frequently a transformer must be used, thus increasing the cost, size and weight of the triggering circuit. If the thyratron transistor that can be switched off is fitted with special devices, switching off can be more convenient. The third section of this article will present a general introduction to various triggering devices.

The various functions of the circuits listed in Table 2 show that electrical devices for daily use have utilized almost all of the various, commonly used circuits of electrical and electronics technology. In application, these devices also possess the same original advantages of electrical and electronic technology (such as energy conservation) and disadvantages (such as interference). Therefore, the problem of how to further develop the advantages and overcome the shortcomings still exists. The control of electrical devices for everyday use is an important link in electrical and electronic technology and an important aspect in the application of electrical and electronic sciences in the realm of small-power devices.

The 1981 annual meeting of the national electrical and electronic science conference, held in Dalian, resolved to advance the study of electrical and electronic technology to serve everyday electrical devices and the light and textile industries. New technologies must be used. The percentage of finished products must be improved. The cost must be lowered to solve the problems

in production techniques for small-power components. At the same time, the meeting also proposed that electrical appliances for daily use must be "reliable, cheap, and safe." These require the manufacturing units to greatly improve the reliability of the components, reduce the prices considerably, and add parts to these products to suppress interference. (In general, the use of an induction capacitor can greatly suppress radiofrequency interference.)

II. Development, Principle, Manufacture, and Application of the Bidirectional Thyratron Transistor

1. Development

The bidirectional thyratron transistor emerged as a type of ideal alternating current control device. In 1963 it was first proposed that only four components would be sufficient to control alternating current, and the proposal received a lot of attention (as shown in Table 2). Commercial production of the thyratron transistor began in 1965 abroad. Our nation began test-producing the first bidirectional thyratron transistor prototype in 1966. The gap was not very large. But later, our nation emphasized the development of high-power bidirectional thyratron transistors, and only in recent years did we begin to emphasize small power bidirectional thyratron transistors for everyday electrical appliances.

The major direction of research in the bidirectional thyratron transistor was to solve the problem in the capability of directional change; therefore, many types of different designs and technological structures emerged. One of the more successful among them was the light-triggered bidirectional thyratron transistor.

The main concern with the low-power bidirectional thyratron transistor was how to solve the problems of producing a high percentage of finished products and of reducing the production costs. Our nation's everyday electrical appliances use 220 volts, but they must use components that draw over 400 volts. Household appliances of foreign nations frequently use a power source of 100 volts, and so components using only 200 volts are needed. This is undoubtedly a factor that is unfavorable to an increase in the percentage of finished products from our nation's manufacturers of components. The use of glass inactivation and plastic sealing benefits reliability and is cheap, but the cost of plastic sealing techniques is frequently related to the size of batch production. Distributing the production of components undoubtedly a factor that is unfavorable to any price reduction.

2. Principle

The operating principle of the bidirectional thyratron transistor has been introduced in some books, and it will not be repeated in much detail here. But many comra's hope that we can give a further description of the mechanism of the third quadrant, because this is relatively unfamiliar to manufacturers and users of ordinary thyratron transistors.

Both the positive and the negative directions of the bidirectional thyratron transistor can trigger conduction. Because the positive direction is in the first quadrant in the volt-ampere characteristic graph, it is called I (i.e., T_1 is positive, T_2 is negative). The negative direction is in the third quadrant in the volt-ampere characteristic graph; therefore it is called III (i.e., T_2 is positive, T_1 is negative).

The gate of the bidirectional thyratron transistor corresponding to the T_2 pole can be positive or negative. Thus the method of triggering conduction can be divided into I_+ , I_- , III_+ , III_- .

The I_+ triggering method is similar to the triggering mechanism of ordinary thyratron transistors.

The I_- triggering method is equivalent to first using the T_2 pole as the gate to trigger the thyratron transistor at the gate (such as the $P_1 N_1 P_2 N_3$ in Diagram 5). Then, via the transverse extention of the conduction zone, the main thyratron transistor $P_1 N_1 P_2 N_2$ conducts. This is similar to the extension in the conducting zone of the amplification gate in the thyratron transistor.

What is less easily understood is why we can use a gate near the T_2 pole (equivalent to the cathode of an ordinary thyratron transistor) to control reverse conduction! During positive conduction, the cathode N_2 region is very close to the gate, while in negative conduction the cathode N_4 region is very far away from the gate. Therefore this has been called "remote control". The following explains the principles of control of the "remote gate."

Taking the III_- triggering method as an example and referring to Diagram 5, we see that this time T_2 is positive and T_1 is negative. At the same time, gate G is more negative than T_2 . First, because T_2 is positive, G is negative, a current flows through the $P_2 N_3$ node; thus the electrons of N_3 are injected into the P_2 zone. To the $N_3 P_2 N_1$ transistor, N_3 is the emitting pole. The emitted electrons are gathered by the integrated circuit pole N_1 . Because T_2 is positive and T_1 is negative, the $P_2 N_1$ node is in the positive direction; i.e., the integrated circuit pole of the $N_3 P_2 N_1$ transistor is in the positive direction. It should be pointed out that the integrated circuit pole node in the positive direction also has an electron-gathering function. This can be understood by noting that the integrated circuit pole is positive when the transistor is in a saturated state. If we go a step further and draw the potential hill graph, we can also see that the potential barrier of the node in the positive direction still benefits the gathering of the few electrons in the base region.

After N_1 gathers the electrons, the polarity at P_2 near N_1 is more negative, causing the $P_2 N_1$ node to be positively biased. Thus, injection of the empty cavity begins from P_2 toward N_1 . The $P_2 N_1 P_1$ transistor acts at this time, and P_1 gathers the empty cavity emitted from P_2 .

These empty cavities will flow towards T_1 . Attention: In the beginning, these currents will flow transversely past the base region of the P_1 zone, and when the bias voltage IR produced on the resistor R in this base region is sufficiently large, $P_1 N_4$ will be positively biased. Thus, electrons begin their injection into N_4 .

Because the two transistors $N_4 P_1 N_1$ and $P_2 N_1 P_1$ have all begun to operate, the current will gradually increase. The amplification coefficients of the two transistors will also gradually increase. When $\alpha_1 + \alpha_2 \geq 1$, $P_2 N_1 P_1 N_4$ will conduct. This is the principle of reverse conduction of the bidirectional thyratron transistor.

It can be seen from this that the conduction of III_- and of the three transistors are related. Written as a formula, it is

$$I = \frac{\alpha_1 \alpha_2 I_G}{1 - (\alpha_1 + \alpha_2)}$$

The denominator should also have the term $\alpha_1 \alpha_3$, but because it is smaller than α_1 and α_2 , it can be omitted. The above discussion shows that transverse resistance R is closely related to the strength of the III_- triggering current. This determines the large influence of the position of the N_4 region below the gate upon the triggering current.

The III_+ triggering method is similar, and will not be repeated here.

The above discussions neglected the short-circuit current between T_2 and G from P to P . Regardless of the triggering method, part of the triggering current flows into the short circuit. In manufacturing, this part of the current is exactly one of the versatile parameters which can be changed at will in the design, and it benefits the symmetry of adjusting the four methods of triggering.

Diagram 5 Structure and conduction mechanism of the bidirectional thyratron transistor

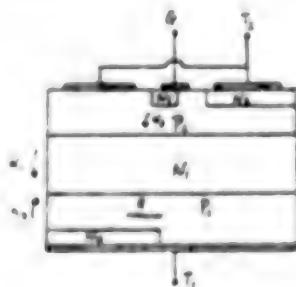


图5.双向晶闸管结构及导通机理

3. Manufacture

The manufacture of the bidirectional thyratron transistor and the manufacture of ordinary thyratron transistors are similar in many aspects. The main differences are:

- (1) The symmetry of the four types of triggering methods must be good. There are many controllable factors in this regard--for example, the amplification coefficients of each transistor, the short-circuit current, the transverse electrical resistance, etc.

(2) Double-surface photoetching must be accurate. This has a definite effect upon the ability of directional change and the triggering current.

(3) Ohm contact: The Ohm contact on the anode T_1 surface is a special problem, because the T_1 surface includes the N region and the P region. To realize a good Ohm contact and avoid damaging the performance of the shallow node, the methods of solving the problem in the large-power bidirectional thyatron transistor and the small-power bidirectional thyatron transistor are not completely the same.

(4) Surface protection, especially the difficulty in retaining voltage after cutting the chips, is a problem. There are definite difficulties in using purely planar technology to reach a high voltage. Glass inactivation is a method. The heat-migration technique also has its advantages.

4. Application

Table 2 gives the simplest form of control of the power of an alternating current of Diac. But when this circuit is used to adjust light, the problem of lagging and jumps cannot be neglected.

Lagging means that when R_H increased to R_{H2} , the bidirectional thyatron transistor is no longer triggered; i.e., $i_L = 0$. Yet when R_H reduces, retriggering the bidirectional thyatron transistor is not possible at $R = R_{H2}$. It must drop to R_{H1} before the component begins conducting. Therefore, between R_{H1} and R_{H2} exists a dual value zone of a different conducting angle. It corresponds to the $i_L = 0$ state and also corresponds to the state in which i_L is not equal to 0. $\Delta R_H = R_{H2} - R_{H1}$ indicates the degree of lag.

Diagram 6 Lagging and jumping phenomena

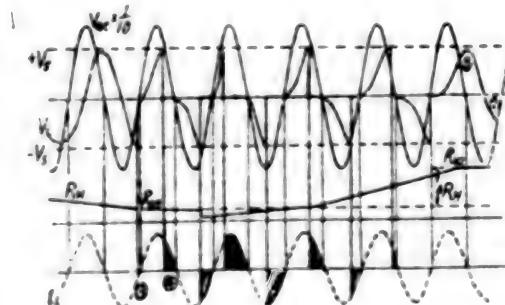


图 6. 滞后及突跳现象

The cause of the lag can also be explained by Diagram 6. When R_H increases to R_{H2} , (See Diagram 6 (1)), it immediately drops by a half-wave. The V_c on the capacitor becomes still smaller than the turning voltage V_s of Diac (See Diagram 6 (2)). Afterward, if R_H does not change, this level will be maintained. We must reduce R_H to cause V_c to rise. When it drops to R_{H1} , V_c will be able to rise to V_s , Diac turns, and the bidirectional thyatron transistor begins conducting. This is the reason that R_{H2} lags to R_{H1} .

Jumping means that when R_H drops to R_{H1} (See Diagram 6 (3)), the next half-wave V_C rapidly rises and moves the conduction angle forward by a large scale. This is a jump. In light regulation, if we begin regulation from complete darkness, the device will not gradually adjust from complete darkness to brightness but will suddenly jump from complete darkness to definite brightness. Of course, this is not desired. The cause of the sudden jumps is also the result of remnant voltage on the capacitor.

For this reason, people have reduced the lag from two approaches. One is to introduce a new triggering device, which will be discussed in the next section. The other method is to improve the circuit--for example, by using the circuit shown in Diagram 7. It is more complex than the circuit listed in Table 2, but C_2 can be utilized to charge C_1 so that after C_1 discharges, a relatively high V_C can be maintained, thus reducing the lag. (The V_C in Diagram 6 (2) is maintained at the level of (1) so that the V_C in (4) approaches the level of (3).)

Diagram 7 Triggering circuit that reduces lagging

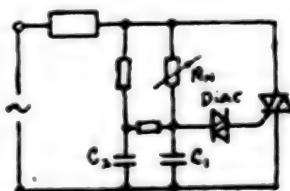


图7. 减小滞后现象的触发电路

Table 2 Characteristics and Triggering Circuits of the Various Triggering Devices

表二、各种触发器件的特性及触发电路
(1) (2) (3)

器件	特性	电路	V_s	i_s	t_{on}
Diac			15-36V	1-2A	1μs
SBS			6-10V	2A	1μs
PUT			$\frac{R_s V_s}{R_s + R_L}$	2A	80μs

Key:

1. Device
2. Characteristics
3. Circuits

III. Introduction to Several Major Types of Triggers

Triggering devices are a big family. They include the following devices:

(1) Unijunction transistors

Unijunction transistors (UJT), complementary unijunction transistors (CUJT), process control unijunction transistors (PUT), equivalent unijunction transistors (EUJT).

(2) Three-layer devices

Bidirectional triggering diode (Diac).

(3) Four-layer devices

Four-layer diodes (FLD, Shockley diode), silicon unidirectional switch (SUS), silicon-controlled switch (SCS).

(4) Five-layer devices

Silicon bidirectional switches (SBS), symmetric silicon switches (SSS) for triggering, asymmetric silicon bidirectional switches (ASBS).

(5) Triggering integrated circuits

Phase-controlled triggering circuits, over-zero triggering circuits, interference-proof triggering circuits.

The above classification is not very exact, because in unijunction transistors, only UJT is truly a unijunction transistor. CJUT is a thyratron transistor with two resistors added; PUT is an N gate thyratron transistor; and EUJT is an integrated circuit consisting of a PUT and transistors.

Similarly, although SUS is a four-layer device, it also has a voltage stabilizer in series. SBS is a five-layer device connected to two voltage stabilizers in series. ASBS is an SBS with a voltage stabilizer connected in series.

This article will give only a brief introduction to these three major types of triggers. We can refer to Table 2. These are also triggering devices which our nation should develop first (UJT has already been produced domestically).

1. Diac

Diac is one of the most common triggering devices. It is actually a symmetric transistor with a basic pole open circuit. Therefore it is the simplest to manufacture. Of course, some difficulties exist and they have to be overcome.

As Table 2 shows: When the turning voltage V_s is reached, negative resistance is produced. This is because the electrons accumulate inside the base region and cancel the blocking layer. It is also the result of $\alpha M = 1$; the larger the α , the larger the negative resistance.

The circuit should be improved as illustrated in Diagram 7 when Diac is used for regulating light.

2. PUT

PUT is a type of N gate thyratron transistor. It can be used as a unijunction transistor, and it can also be used as a small thyratron transistor; it is a thyratron transistor that is especially sensitive to triggering. This is because the controlling current from the gate to the cathode always flows in a longitudinal direction.

PUT can be made in a transverse or a longitudinal structure. If another electrode is extended from the P base region of a PUT, it actually becomes an SCS.

When a PUT is used as a unijunction transistor, it must be fitted with an electrical resistor, as shown in Table 2. Because the electrical resistance can be changed at will, the required V_s , the peak current I_p and the trough current I_{v} can be designed. The process-control unijunction transistor gets its name "process control" from this.

PUT is a direct current device.

3. SBS

SBS is actually a planar transverse bidirectional thyratron transistor. Because it is connected to two voltage stabilizers in series, its voltage is determined by the voltage stabilizer, and the voltage is lower.

When using the SBS triggering circuit, the SBS gate can be utilized to trigger the SBS. Therefore the remanent voltage on the capacitor can be completely drained, thus eliminating the lagging effect.

The manufacturing technology of SBS is similar to that of the PUT transverse structure. Because it is of a planar structure, its voltage characteristics are easily obtained. The other major characteristics are similar to those of PUT, but it is a bidirectional device.

At present there are more production plants, and it is completely possible to produce the various types of triggers described above by a division of labor. But popularizing a new device requires the coordination of many circuits. The triggering integrated circuit should also be developed. In particular, the over-zero triggering circuit is very useful for solid-state relays.

In the push to develop electrical appliances for everyday use, the various types of electrical semiconductor devices have undergone new development. At this time, we should strengthen leadership and organization and strengthen cooperation and exchanges in order to make new contributions to the development of our nation's electrical and electronic technology.

FOOTNOTES

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CSO: 4008/111

APPLIED SCIENCES

COMPUTER USED FOR CONSTRUCTION PROJECTS IN CHANGZHOU

Nanjing XINHUA RIBAO in Chinese 24 Jan 82 p 1

[Article by Ju Zhenqiu [1446 7201 3808]: "The 'Electronic Brain' Enters the Building Industry"]

[Text] Starting 1 January, the small electronic computer, which people call an "electronic brain", has begun to replace preliminary accounting personnel in some units of the Changzhou municipal construction and engineering system to carry out the task of compiling preliminary accounts for civil engineering projects. This new achievement in scientific research is a welcome step toward the gradual realization of modernization in technology and management in construction enterprises.

This small electronic computer for use in the construction industry was successfully developed by the Fourth Engineering Department of the Changzhou Municipal Construction Engineering Bureau, in cooperation with the Second Changzhou Radio Plant. They spent 11 months and conducted several hundred tests. This computer is small, lightweight, has a low construction cost, computes accurately, and has a stable performance. On 26 and 27 December last year, it passed evaluation [tests] and received praise. This computer can compile and print one preliminary account in half an hour including complete data on the code number of the project, the area of building, building costs, the amount of work, and the consumption of materials. It saves three-fourths the time required manually, and it has shortened the compilation period. At the same time, the computer's data are accurate, it avoids the errors and mistakes of manual calculations, and it improves work efficiency.

At present, the First, Fourth and Sixth Departments of the Changzhou Municipal Construction Engineering Bureau, the Changzhou Municipal Building Design Office, and the Changzhou Residential Housing Company have begun using this computer to compile preliminary accounting data for construction projects.

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APPLIED SCIENCES

USE OF PORTABLE TI-59 COMPUTER BEING POPULARIZED

Beijing SHUILI SHUIDIAN JISHU [WATER CONSERVATION AND HYDROELECTRIC POWER TECHNOLOGY] in Chinese No 1, 1982 p 65

[Article provided by Yuan Tanlin [5913 2905 2651]: "Popularization and Use of the TI-59 Computer in Hydraulic Engineering Design"]

[Text] In recent years, the programmable TI-59 computer introduced into our nation is being used more widely and has been welcomed. The computer is a portable, handheld computer. Its functions are between those of a computer and those of a function calculator. Relatively long programs can be compiled, and the computer is fitted with a program library composed of large-scale integrated circuits. It can perform some of the functions of a small computer.

To study the possibility of using that computer in hydraulic engineering design, the Planning and Design Management Bureau of the Ministry of Water Conservancy held a short computer training class for the hydraulic engineering profession in Beijing from 5 to 15 December 1981. Fifty students from the water-conservancy and hydroelectric design units subordinate to the ministry and of 26 provinces and cities participated in the training class. Professor Zhen Fengshi [6774 6646 2514] of Qinghua University and engineer Guan Yinghua [7070 5391 5478] of the Beijing Survey and Design Academy of the Ministry of Water Conservancy taught the use of the computer, techniques for compiling programs, and methods of compiling applications programs for hydraulic engineering. During this brief learning period, the students compiled on a trial basis more than 30 types of programs, including programs for antislippage stabilization of the whole equal K body of the dam shoulder of an arch dam, antislippage stabilization of a gravity dam, programs for the slipping arc of the slope of an earth dam, waterjump, water surface lines of exposed canals, seepage, and stress calculations for photo-elasticity tests. They expressed their belief that as long as forces are organized to compile general-purpose programs, many regular methods of standard computation in hydraulic engineering design can all be done by programmed computations on the TI-59 computer. This computer is more suitable for repeated computations and for trial-and-error calculations in solving equations of implicit functions.

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SK231213 Harbin Heilongjiang Provincial Service in Mandarin 1100 GMT
22 Apr 82

[Excerpts] The provincial post and telecommunications work conference concluded today. Chen Lei, secretary of the provincial CCP committee and provincial governor, addressed the conference. He pointed out: accelerating post and telecommunications construction, strengthening the capacity of communications, easing the strained situation in communications, improving the service and quality of this work and raising economic results are tasks of top priority in post and telecommunications construction.

Chen Lei said: In carrying out current post and telecommunications work, we must pay attention to some key points. First, we must install local telephones in large and medium-sized cities and in industrial and mining areas; second, we must grasp well communications work in the border areas. All planning and construction departments of large and medium-sized cities must bring the plans of installing local telephones and establishing post and telecommunications service network into line with the urban construction plan.

While addressing the issue of improving post and telecommunications service and improving quality and economic results, Chen Lei stressed: post and telecommunications are matters concerning the welfare of each and every family. Their purpose is to serve society as a whole and to keep in touch with the people and the masses. Post and telecommunications departments and personnel concerned must foster the idea of serving the people and being responsible for the users, regard the degree of satisfying the needs of society as the highest standard for examining post and telecommunications service work, resolutely overcome the Yamen work style and launch service activities aimed at treating people politely, providing good service, giving convenience to the masses and safeguarding the departments' reputation. In addition, departments concerned must also overcome conservative ideas and actively carry out all kinds of post and telecommunications businesses that are urgently needed in society and provide good economic results.

CSO: 4008/164

APPLIED SCIENCES

OPTICAL FIBER MANUFACTURING TECHNIQUE DESCRIBED

Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese No 1, 1982 pp 33-38

[Article by Teng Yucai [6772 6757 2088], Luo Huiying [5012 1979 5391], Wang Yanfang [3769 5333 5364], Xiong Jiancun [3574 1696 4783], and Wang Shubin [3769 3219 2430] of the Wuhan Postal and Telecommunications Science Research Institute: "Using the Microwave Plasma Activated Chemical Vapor Deposition Method to Prepare Low-Loss Optical Fibers"; article received by this journal on 10 August 1981]

[Text] This article describes the basic principles and the main characteristics of the equipment developed for the microwave plasma-activated chemical vapor deposition method. At the same time, it describes the basic data on using this method to prepare optical fibers drawn from preforms. The multimode step index optical fiber presently prepared has a loss reaching 5 dB/km (at a wavelength of 0.85 μ m). The lowest loss is 2.84 dB/km (at a wavelength of 1.07 μ m). The efficiency of deposition of the raw material has already surpassed 90 percent.

I. Introduction

The optical communications fibers presently in use are mostly quartz fibers prepared by the chemical vapor deposition method (abbreviated the CVD method). The manufacturing techniques can generally be divided into the outside vapor phase oxidation technique (OVPO) and the inside vapor phase oxidation technique (IVPO). The former includes the outside vapor phase deposition method (abbreviated the OVD method) and the vapor phase axial deposition method (abbreviated the VAD method). The latter includes the modified chemical vapor phase deposition method (abbreviated the MCVD method). This article discusses the microwave plasma activated chemical vapor phase deposition method (abbreviated the PCVD method).

The outside vapor phase oxidation technique is complex. Under ordinary conditions, it does not easily produce high-quality optical fibers. In the inside vapor phase oxidation technique, the reaction occurs inside a tube; therefore, it is easier to avoid pollution by the outside environment, and

low-loss optical fiber can be produced. In the MCVD method, oxyhydrogen flame is used as the heating source. The procedure is simple, and so this method is mostly used domestically.

In the MCVD method, because the deposition temperature reaches as high as 1400° C to 1600° C, the vapor phase reaction first forms an oxidized dust, and then the dust is melted. The core layer generally can only deposit about 60 layers of variable concentrations of a nearly ideally distributed refractive index. Therefore, control over this method is more difficult. Consistency is poor, the bandwidth characteristics are not good enough, and the deposition efficiency is low (generally 15 to 30 percent).

The PCVD method has these major advantages over other methods: it does not use oxyhydrogen flame for heating. The deposition temperature is only about 100° C. Control is good. Thickness of the deposited layers can be smaller than 1 μm. The core layer of the optical fiber can deposit up to 1,000 layers of variable concentrations of a nearly ideally distributed refractive index. The optical fiber has good geometric and optical characteristics. In particular, the bandwidth is wider and repeatability is good. The deposition efficiency is high, approaching 100 percent.

Current reports indicate the high-quality multimode gradient fibers have been produced 2. It is expected that this will also demonstrate its unique advantages in preparing single-mode optical fibers.

This article mainly describes the fundamental principles and the major characteristics of the equipment developed for the PCVD method. At the same time, it describes the basic data for preparing optical fibers drawn from preforms using this method. The loss of the multimode step index optical fiber currently prepared is 5 dB/km (at a wavelength of 0.85 μm); the lowest loss is 2.84 dB/km (at a wavelength of 1.07 μm); and the deposition efficiency can reach a high of over 90 percent.

II. Basic Principles

The major characteristics of the PCVD method is the use of nonisothermal plasma (also called cold plasma) as the reaction source, as shown in Diagram 1. When highly pure gilades SiCl₄ and GeCl₄ are carried into the reaction tube by carrier O₂, they enter the strong electrical field region of the resonance cavity. The raw material gas is excited and ionized, maintains a glow discharge, and forms a nonisothermal plasma. The neutral molecules of the various raw materials are ionized to become charged particles (electrons, cations, anions) and charge-free particles (atoms of the gas, molecules, excited atoms, semi-stable atoms). The silicon and oxygen combine to form SiO₂. It deposits, via expansion, on the inner surface of the reaction tube. This is a type of chemical effect of microwave discharge.

The main characteristic of the PCVD method is that its reaction temperature is lower than the corresponding temperature of heated reactions. This brings about a series of advantages in preparing optical fibers.

Because ionization of gas is not limited by the thermal capacity of the reaction tube, the resonance cavity can move back and forth quickly along the reaction tube. Thus up to 1,000 layers of extremely even, transparent, thin layers can be prepared. Because there is no pulverization process, the deposition efficiency is high.

The temperature of the preheating furnace surrounding the reaction tube is about 1100° C. Its function is to maintain matching temperatures between the inner wall of the reaction tube and the depositing layers so as to avoid cracking in the depositing layers and at the same time to reduce the chlorine content in the bubbles produced in the depositing layers.

The PCVD method prepares optical fibers generally in three stages: the first stage is to deposit the core layer inside the reaction tube (the final layer becomes the wrapping of the optical fiber). The second stage is to heat the layers with an oxyhydrogen flame to 1900° C - 2000° C and condense them by melting into a solid rod of the "preform." The third stage is to use the graphite furnace to reheat the preform to about 2000° C and then draw the rod into optical fibers.

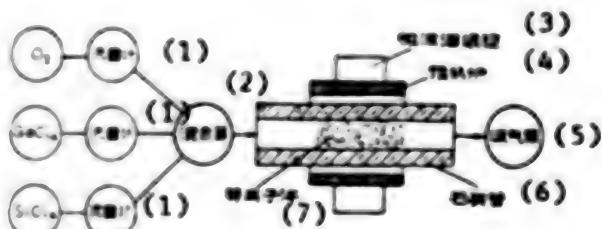


图 1 PCVD 原理图

Diagram 1. Illustration of the principles of the PCVD method

Key:

- | | |
|-------------------------------|------------------|
| 1. Fluviometer | 5. Sunction pump |
| 2. Mixer | 6. Quartz tube |
| 3. Microwave resonance cavity | 7. Plasma |
| 4. Preheating furnace | |

III. Experimental Equipment

The PCVD equipment we developed mainly consists of the following four parts as shown in Diagram 2.

1. Microwave System

The microwave system consists of a continuous-wave magnetic control tube with an operating frequency of 2450 MHz and a maximum output of 150 W, a plasma resonance cavity, and corresponding waveguide elements.

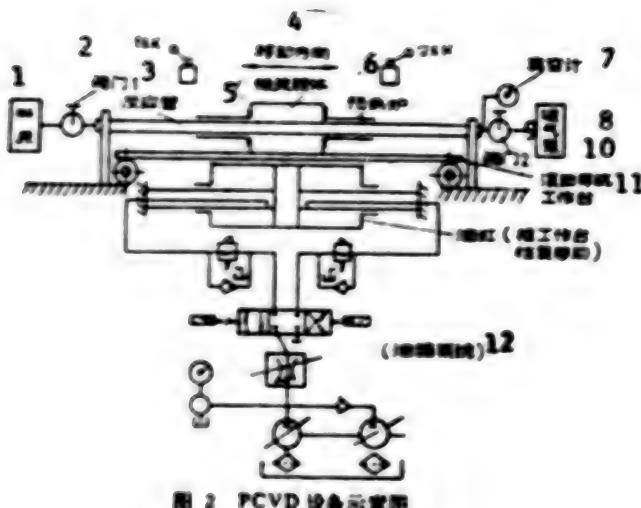


图 2 PCVD 设备示意图

Diagram 2. Illustration of PCVD equipment.

Key:

- | | |
|--------------------------|------------------------------------|
| 1. Material source | 8. Suction pump |
| 2. Valve 1 | 9. Valve 2 |
| 3. Reactor tube | 10. Roller guide rails of the work |
| 4. Direction of movement | platform |
| 5. Microwave cavity | 11. Fuel tank (for moving the work |
| 6. Preheating furnace | (platform back and forth) |
| 7. Vacuum gauge | 12. (Fuel pipe system) |

According to technological requirements, a reentry resonance cavity is more suitable. The reentry cavity we developed uses ring coupled input. Under actual experimental conditions (with an operating pressure of 5 torr, and input power of 150 W), glow discharge can be produced without using the Tesla coil for excitation. The maximum volume of the plasma produced can surpass 20 cm³. The longest plasma column can surpass 20 cm, completely satisfying the requirements of the PCVD method 3.

The connection between the microwave cavity and the magnetic control tube is a 30 dB directional coupler serving as a power monitor, and 50Ω coaxial wires are used to connect the N joints, as shown in Diagram 3.

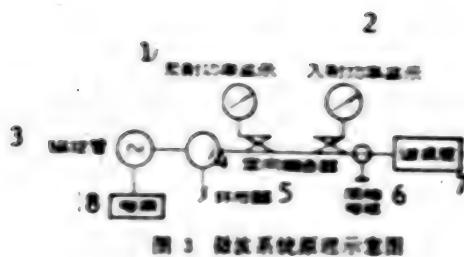


Diagram 3. Illustration of the principles of the microwave system

Key:

- | | |
|----------------------------|---------------------------|
| 1. Reflected power monitor | 5. Directional coupler |
| 2. Incident power monitor | 6. Coaxial electric cable |
| 3. Magnetic control tube | 7. Resonance cavity |
| 4. Ring | 8. Power source |

2. The Vapor System

In front of the reaction tube are various raw materials (SiCl_4 , GeCl_4 , O_2) and corresponding fluvimeters, a bulging bubble flask, and a mixer. To prevent impurities in the air from entering the system, a working state slightly more positive than the atmospheric pressure is maintained in front of valve 1. At the end of the reaction tube is a suction pump and a vacuum gage. By adjusting valve 2, a working pressure of 1 to 30 torr can be maintained inside the reaction tube.

3. The Reactor

This consists mainly of a reaction tube, a resonance cavity, and a preheating furnace. The reaction tube is stationary. It is a quartz tube with an outer diameter of 10 mm and an inner diameter of 8 mm. A water-cooled resonance cavity and a preheating furnace are installed together, and they can move back and forth.

4. Smelting Lathe

To realize back-and-forth movement in a straight line with stepless speed regulation along the distance $L = 0$ to 80 cm, a hydraulic transmission lathe is used. Its advantages are as follows: it is easy to realize back-and-forth movement in a straight line to directly drive the operating mechanism. It can perform stepless speed regulation within a relatively large range. The motion of transmission is smooth and steady and maintains an even speed, which enables the thickness of the deposits to be even. It is easy to realize automatic transmission and control. The structure and circuitry of the mechanism are simple, and its useful life is long.

The distance of the work platform of the smelting lathe $L = 0$ to 80 cm is continuously adjustable. The speed of motion is $V = 0.4$ to 20 m/min with

stepless speed regulation. The variation in speed is no larger than 20 percent, and the rise in temperature is smaller than 10° C.

IV. Results of Deposition Experiments and Discussion

1. Stationary Experiment

The resonance cavity and the reaction tube are stationary, mainly to study the deposition of pure SiO₂.

The raw materials are SiCl₄ and O₂. Reaction under room temperature produces SiO₂, deposits, but there are large areas of cracks, and the layers shed easily after a certain thickness has been reached. This is caused mainly by the temperature of the wall of the reaction tube being too low and by its not matching the temperature of the deposits. Stress appears, and the chlorine content in the deposit becomes too high. When the temperature of the preheating furnace is raised to over 800° C, highly even and transparent SiO₂ deposits are produced.

The plasma column is basically symmetrical to the center of the cavity. The greater the input power or the lower the working pressure, the longer the plasma column. The main portion of deposition does not occur at the center of the cavity but several centimeters away from the center of the cavity, toward the vapor intake end. This is because, when raw material gases enter the plasma column, chemical reaction begins and deposits begin. The length of the deposits and the deposition efficiency are determined mainly by the velocity of the flow V_m of the raw material gas inside the reaction tube. The velocity of flow V_m can be given by the following formula:

$$V_m = Q/\pi \cdot r^2 \cdot p' \quad (1)$$

where Q is the value of total flow.

p' is the ratio between the working pressure and the atmospheric pressure.

r is the inner radius of the reaction tube.

When V_m equals several hundred meters per minute, the raw material gas stays in the plasma column for several dozen milliseconds, and a relatively short deposition length of 1 to 2 cm can be obtained, with a relatively high deposition efficiency of over 90 percent.

Deposition efficiency η
defined as

$$\eta = \frac{\text{Weight of deposits of oxides from converted hilades}}{\text{Weight of deposits of oxides from complete conversion of hilades}} \quad (2)$$

The experimental results of the deposition efficiency of SiO_2 are shown in Diagram 4. The solid line in the diagram represents the theoretical value of $\eta = 100$ percent. It is calculated from the equation of the chemical reaction.

It can be seen from the diagram that the highest η is about 95 percent, and it is generally near 80 percent. It can be seen from the experimental results with these basically similar conditions that the larger the Q (i.e., the larger the consumption of SiCl_4), the lower the η (as shown by the dotted lines in Diagram 4). This was caused mainly by an overly large velocity of flow V_m . It was also discovered that the exit of the flask containing the raw material gas had been leaking. This was another reason why the experimental value of η was low.

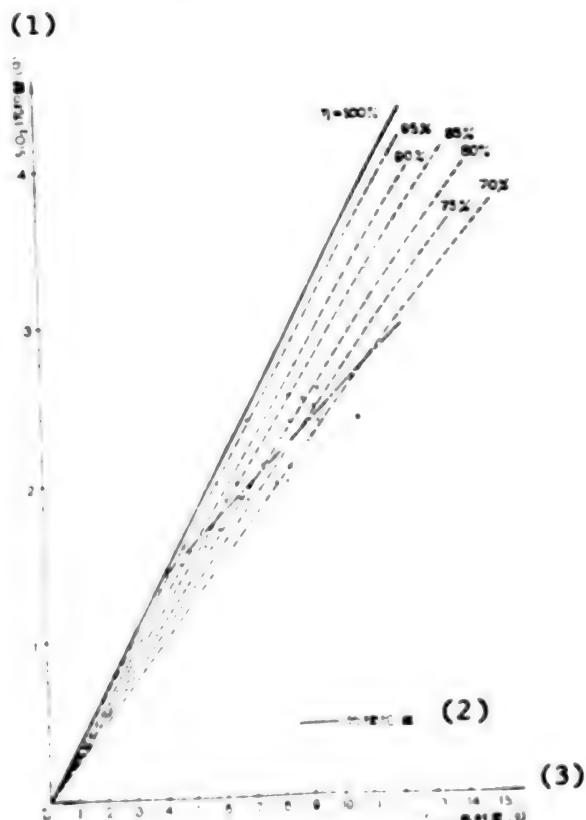


Diagram 4. Theoretical and experimental values of the deposition efficiency

Key:

- | | |
|-----------------------|----------------|
| 1. Amount of deposits | 3. Consumption |
| 2. Theoretical values | |

2. Dynamic Experiment

As the resonance cavity moves back and forth relative to the reaction tube, even, transparent, and thin layers deposit along the inner wall of the reaction tube. We discovered that when the temperature in the preheating furnace was about 1000° C, large air bubbles emerged in the depositing layers during the melting and condensation stage, even though the depositing layers were still transparent. When the temperature of the preheating furnace was above 1100° C, this phenomenon was eliminated. According to analysis using the method of neutron excitation by Kuppers, et al, we know that the chlorine content in the depositing layers drops as the temperature of the preheating furnace rises. For example, at 980° C, the chlorine content drops as the temperature of the preheating furnace rises. For example, at 980° C, the chlorine content increases to 1 wt %, while at 1050° C its content is only 0.1 wt %. The main cause of the occurrence of air bubbles is the release of chlorine under high temperatures.

The experiments of mixing impurities (GeO_2 , P_2O_5 , B_2O_3) in SiO_2 all produced satisfactory results.

Experiments were conducted to examine the ratio of the refractive index and the amount of flow of the carrier gas of SiO_2 glass after mixing in Ge. If the amount of the impurities mixed into the glass is small, the ratio between the variation of the refractive index caused by the mixing of impurities and the amount of impurities can be considered directly proportional 5. The experimental results are shown in Diagram 5.

In the diagram, "•" [the dots] are the test results. Their deviation from the straight line, according to analysis, is due mainly to poor precision of the fluviometer and different levels of the surface of the liquid in the material supply flask during each experiment.

3. Preparation of the Multimode Step Index Optical Fiber

The PCVD method for preparing multimode gradient optical fibers has its unique advantages. Because of a lack of corresponding flow-control equipment at present, only research in the preparation of the step index optical fiber has been conducted. The optical fiber has a structure that is illustrated in Diagram 6.

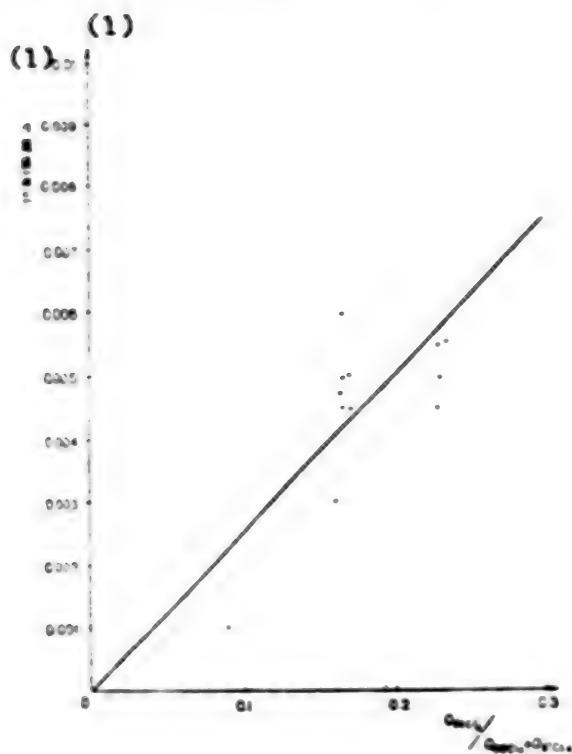


Diagram 5. The ratio between the difference in the refractive indices and the amount of flow of the carrier gas.

Key:

1. Difference in refractive indices

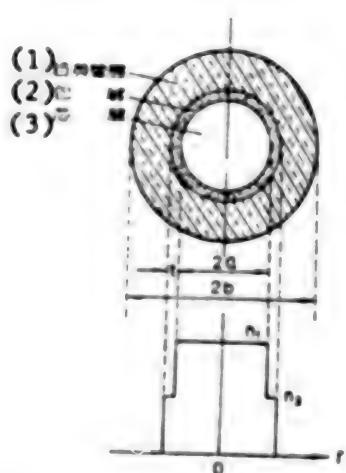


Diagram 6. Structure of the optical fiber: Outer diameter is $2b$; diameter of the core is $2a$; refractive index is n_1 ; thickness of the wrapping layer is t ; refractive index is n_2 .

$$\Delta = \frac{n_1 - n_2}{n_1} .$$

Here, t is the wrapping layer formed by the highly pure glass deposits. It serves to reduce the added loss in the percolation field in the core, to block any thermal expansion of the transient metallic ions and OH^- ions toward the core in the quartz tube, and to improve the loss characteristics of the optical fiber. Combining the various considerations, we can generally determine the structure of the optical fiber as follows:

At $\lambda = 0.8 \mu\text{m}$, $\Delta = 1 - 0.7$ percent, $2b = 125 \mu\text{m}$, $2a = 50 \mu\text{m}$, $t = 10 - 15 \mu\text{m}$.

Wrapping layer material: pure SiO_2 glass structure.

Core layer material: $\text{SiO}_2 - \text{GeO}_2$ binary system glass structure.

Raw materials: O_2 is at the electron level; the purity of SiCl_4 and GeCl_4 is 99.9999%; the quartz reaction tube is a second-grade electrofusion tube.

The typical data of deposition are $Q_{\text{O}_2} = 10 - 20 \text{ ml/min}$, $Q = 50 \text{ ml/min}$, $Q_{\text{GeCl}_4} = 15 \text{ ml/min}$. The working pressure is $P = 8 - 10 \text{ torr}$. The temperature of the preheating furnace is $T_f = 1150^\circ \text{C}$. The microwave input power is $P = 150 \text{ W}$. The cavity traveling speed is $V = 2.4 \text{ m/min}$. The distance of travel is $L = 20 \text{ cm}$. The number of deposited wrapping layers is about 700 layers, and the deposited core layers number about 1,000 layers.

After deposition, the tube is melted and condensed over an oxyhydrogen flame to a solid rod of an outer diameter of about 7 mm and a length of about 20 cm. Finally, the rod is drawn in a graphite furnace into an optical fiber about 500 m long.

The above method was used to prepare some optical fibers. The best fiber among them has been analyzed as follows:

The distribution of the refraction index of the fiber was tested. The outer diameter of the fiber was $125 \mu\text{m}$. The diameter of the core was 44 to 48 μm , $N \cdot A = 0.16$, and the core had an ellipticity of 2 percent. This is because, during the melting and condensation stage, positive pressure was not added inside the tube and contraction was uneven.

The cutting method was used to measure the loss. At a wavelength of $0.85 \mu\text{m}$, the loss was 4.3 dB/km . The curve of the optical spectrum of the loss is shown in Diagram 7: Within the range from 0.8 to $0.87 \mu\text{m}$, the loss was about 5 dB, basically consistent with the results obtained by the cutting method. The loss at the absorption peak of the OH^- harmonic on the $0.95 \mu\text{m}$ wavelength reached a high of 54 dB/km . This was due to pollution by over 50 ppm of OH^- . According to analysis, this was caused mainly by imperfections in the system of vapor channels. If OH^- pollution is reduced, the loss over the entire wave segment can be expected to drop by a relatively large scale. At $1.07 \mu\text{m}$ wavelength, the least loss was 2.84 dB/km .

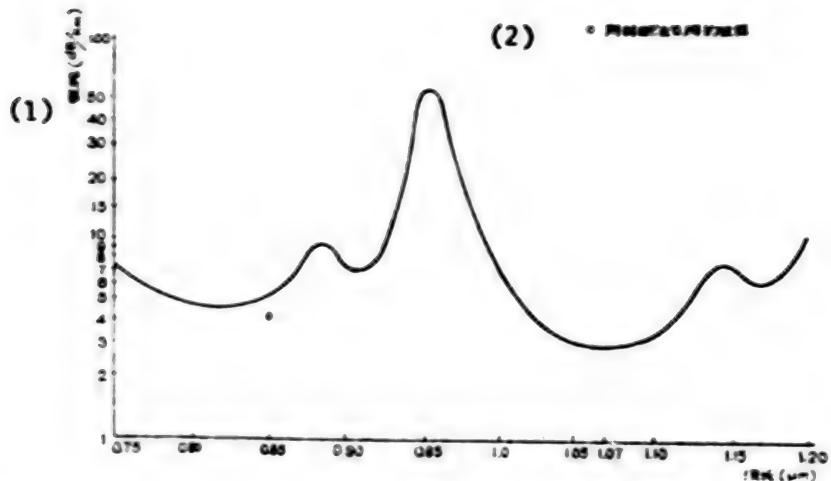


Diagram 7. The curve of the optical spectrum of attenuation and loss of a $\text{GeO}_2 - \text{SiO}_2$ optical fiber.

Key:

1. Attenuation and loss 2. Data measured by the cutting method

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APPLIED SCIENCES

BRIEFS

MAGNETIC RECORDING TECHNOLOGY--Lanzhou, 23 Apr (XINHUA)--The hot-pressed ferrite material used in magnetic recording heads, developed by Lanzhou University, northwest China, has reached advanced world level in major technological norms according to appraisals by the Ministry of Education. Five types of hot-pressed ferrite materials have been developed in recent years by the university's magnetism laboratory, led by associate Professor Yang Zhen, vice chairman of the Society of Applied Magnetism under the Chinese Institute of Electronics. The material for making magnetic heads is essential for developing magnetic recording technology, which is widely used in industry, agriculture, scientific research and education. The technology has a high recording density, costs little and preserves recorded messages for a long time. [Text] [OW251341 Beijing XINHUA in English 0737 GMT 23 Apr 82 OW]

HEILONGJIANG MICROWAVE-CIRCUIT DIALING--Beginning on 21 April, Harbin, Qiqihar, Mudanjiang and Daqing municipalities, Heilongjiang Province, opened the microwave-circuit long-distance dialing service to places throughout the country. [Harbin Heilongjiang Provincial Service in Mandarin 2200 GMT 21 Apr 82 SK]

CSO: 4008/164

LIFE SCIENCES

HUNAN HOSTS NATIONAL CHINESE MEDICINE CONFERENCE

HK240244 Changsha Hunan Provincial Service in Mandarin 2310 GMT 23 Apr 82

[Text] A national Chinese medicine work conference concluded in Hengyang on 22 April. The conference proposed: Chinese medicine hospitals and institutes of higher education must give further prominence to the characteristics of Chinese medicine, bring into play its superior features, and strive to medical studies, so as to make contributions to people's health and socialist modernization.

Chinese medicine has recorded notable achievements since the third plenary session, because the leaders at all levels have attached importance to it. The Chinese medicine organs have been revived and developed. Leaders and public health administrative departments at all levels have paid attention to the role of Chinese medicine in keeping the people healthy, and have shown great concern and provided great support for it.

During the conference, representatives of Shaanxi, Jiangsu and Hubei Provinces, Jinzhou Municipality in Liaoning, the Hunan Provincial Public Health Department, and Hengyang Prefectural Public Health Bureau introduced their experience in mobilizing the enthusiasm of all quarters and supporting the development of Chinese medicine hospitals.

The participants held discussions on the question of how to maintain the characteristics of Chinese medicine and run the Chinese medicine hospitals well. The Chinese medicine hospitals including those in Wuhan and Hengyang Municipalities have applied Chinese medicine theory to guide their diagnosis and treatment work and maintained the orientation of applying the characteristics of Chinese medicine to run the hospitals. The conference praised their experiences.

The Hunan Provincial Public Health Department simultaneously held a provincial conference on Chinese medicine work. The representatives attending these two conferences visited Chinese medicine hospitals in Hengdong, Qidong, Qiyang and Hengyang.

CSO: 4008/163

LIFE SCIENCES

BRIEFS

MEDICAL WORK IN THIRD WORLD--Beijing, 16 April XINHUA LAA Chinese medical teams have treated more than 52 million patients in West Asia and Africa in the past 19 years, according to a meeting yesterday of the medical and public health section of the national committee of the Chinese people's political consultative conference. Xue Gongchuo, director of the foreign affairs bureau of the Ministry of Public Health, described China's medical work abroad. He said 34 teams staffed by 1,075 medical workers have been working in West Asia and Africa since 1963. Teams have been sent to 41 countries and regions, rendering both treatment and training to a great number of personnel in the third world. Members of the C.P.C.C. national committee attending the meeting said it is very important for China to send medical teams to the third world, promoting a link between the Chinese people and those in the third world. Efforts should be made to strengthen and improve the work, they said. [Text] [OW162212 Beijing XINHUA in English 1618 GMT 16 Apr 82]

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- The Investigation of Spheroidal Graphite in Iron-Carbon AlloyChen Xichen [7115 3356 3819], Wang Zulun [3769 4371 0178] and Yi Sunsheng [2496 1327 5110], et al., all of the Institute of Physics, Chinese Academy of Sciences (15)
- The Investigation of Fatigue Crack Initiation and Propagation Mechanism for Nodular Cast Iron.....Hu Zhizhong [5170 1807 1813], Guo Dazhan [6753 1129 1455] and Zhang Pingsheng [1728 1627 3932], et al., all of the Strength Research Institute, Xi'an Jiaotong University (25)
- Extra-fine Metal-cutting for High-Phosphorus Cast Iron.....Chen Yueyao [7115 2574 2565] and Lu Wenxiang [4151 2429 4382], both of Huazhong Institute of Technology (33)
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Discussion on Deformation of Earth-Rock Dams and Analysis of
Cracking and Shearing Rupture of These Dams.....Bian Fuzong
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Research Works of Rock Mechanics in Laboratorio Nacional de
Engenharia Civil, Lisbon, Portugal.....Huang Renfu [7806
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Engineering in China, 1981.....Editorial Office

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CSO: 4008/145

Civil Engineering

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TITLE: "A New Method for Determining Cohesive Soil Earthquake Pressure and Its Point of Application"

SOURCE: Beijing TUMU GONGCHENG XUEBAO [CHINA CIVIL ENGINEERING JOURNAL] in Chinese No 1, 1982 pp 45-54

TEXT OF ENGLISH ABSTRACT: This paper presents a new method for determining the earthquake pressure and its point of application of cohesive soil. On the assumption of plane rupture, formulas are derived for general computer work and, further, this new plane assumption method is compared with the existing and better one. Through examples the effect of various factors is analyzed and a preliminary conclusion is made accordingly.

As the rational conclusion from the achievement of dynamic study is taken into account in the derivation of the formulas, the point of application of the active (passive) earth pressure appears to be higher (lower) in position, which makes the intensity diagram of the active pressure approach more closely the results of FEM analysis. This not only improves the static assumption, but also makes it safer than the existing plane method. The new formulas are clear in physical meaning and rather convenient for taking care of the effect of various factors.

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TITLE: "On the Lateral Pressure of Tunnel Linings"

SOURCE: Beijing TUMU GONGCHENG XUEBAO [CHINA CIVIL ENGINEERING JOURNAL] in Chinese No 1, 1982 pp 55-62, 54

TEXT OF ENGLISH ABSTRACT: Based on actual measurements of both the lateral pressure sustained by tunnel linings and the internal stresses induced in them, an analysis is made in combination with the cracking and displacement which indicates that the observed lateral pressure is larger than that stipulated in the current Railway Design Specifications, and the practical rock characteristics are more variegated than those catalogued in the specifications. After a briefing of the deformation and stress redistribution in the surrounding rock, the author emphasizes the importance to design practice of the semi-empirical formulas concluded from site measurements.

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CSO: 4009/301

Geology

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TITLE: "A Method of Earthquake Analysis of Soil-structure Interaction Problem"

SOURCE: Shanghai TONGJI DAXUE XUEBAO [JOURNAL OF TONGJI UNIVERSITY] in Chinese
No 1, 1982 pp 1-13

TEXT OF ENGLISH ABSTRACT: In this paper the advantages and disadvantages of the mass-spring system and FEM are briefly described in analyzing the soil-structure interaction problem. Furthermore, a modified substructure method is developed based on the general substructure method, taking into account the relative displacements on both sides of the interface. The assumption that the foundation be welded to the ground will no longer be necessary when using this method. The calculated results show that the effect of the relative displacements on the response of the system will be larger in the region adjacent to the foundation.

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TITLE: "Basic Features of Clastic Rocks of the Lower Tertiary Funing Group, North Jiangsu, with Reference to the Source Problem of Its Material"

SOURCE: Shanghai TONGJI DAXUE XUEBAO [JOURNAL OF TONGJI UNIVERSITY] in Chinese
No 1, 1982 pp 60-72

TEXT OF ENGLISH ABSTRACT: From four aspects, i.e., the composition of the terrigenous clasts and the typomorphic features of the minerals, authigenic minerals, cements and matrix, the type of clastic rocks as well as the changes taking place after the burial of the sediments, this paper clarifies the basic features of the clastic rocks of the area. Some of their features indicate that the sediments were transitional in nature between the meritic sea and land, and were influenced by the action of saline water and fresh water dually and successively. The changes taking place after the burial of the sediments have some effects on their physical properties. As for its source of material, it is multi-originated, although it mainly owes its origin to the metamorphic rocks and granite mass in the southwestern margin of the basin.

Metallurgy

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TITLE: "The Changes of Phase Compositions and Hardening of Panzhihua Iron Concentrate Pellets"

SOURCE: Chongqing CHONGQING DAXUE XUEBAO [JOURNAL OF CHONGQING UNIVERSITY] in Chinese No 1, 1982 pp 1-10

TEXT OF ENGLISH ABSTRACT: In order to find out the hardening mechanism of the V-Ti-bearing iron ore concentrate pellets, this paper presents the laboratory research results on phase composition and pellet hardening changes. The oxidizing reactions, structure of briquettes and the effects of high temperature roasting and of carbonate additives on the structure of the pellets are discussed. Investigation revealed that good quality pellets may be obtained by roasting at 1250°C the briquettes made with fine ground iron concentrates. The size of Hematite crystals does not materially affect the hardening, but the effect of recrystallization is important for the reformation of the structure of the pellets, i.e., the solid reaction forms close

[Continuation of CHONGQING DAXUE XUEBAO No 1, 1982 pp 1-10]

packing of stable Titanium-Hematite with other minerals. The hardening of Panzhihua iron concentrate pellets mainly depends on the completeness of oxidation, proper control of the roasting temperature and slag phase, forming a stable structure and phase composition with Titanium-Hematite as a framework or skeleton.

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TITLE: "An Ellipsometric Study for the Growth of Surface Films on Titanium
in Chloride Solutions"

SOURCE: Chongqing CHONGQING DAXUE XUEBAO [JOURNAL OF CHONGQING UNIVERSITY] in
Chinese No 1, 1982 pp 11-19

TEXT OF ENGLISH ABSTRACT: In order to determine the corrosion resistance of titanium in HCl and NaCl solutions, the progress of the surface film growth on titanium in these solutions was studied by ellipsometry. Results showed that the rate of growth of surface film on Ti follows the direct logarithmic law only at the initial stage, with the rate turning to parabolic law after the film reaches a certain thickness. This shows that the corrosion resistance of the surface film of titanium is not very good. In this paper, the anodic polarization and breakdown potential of titanium in chloride solutions are also investigated. The problem of improving the corrosion resistance of titanium is discussed, too.

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